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OPPORTUNITIES FOR PV APPLICATIONS

John A. Scott-Monck (Workshop Cochairman)
Jet Propulsion Laboratory
Pasadena, California

and

W. Patrick Rahilly (Workshop Cochairman)
The Aerospace Corporation
Los Angeles, California

Rather than dwell on the obvious future applications that could be satisfied by photovoltaics (PV), the workshop members devoted the majority of the time to discussing future prospects for technology support. PV has provided power for almost every spacecraft launched in the free world during the past 25 years. Over this time, PV has demonstrated impressive growth in power level, operating lifetime and specific power (W/kg and W/m^2). Yet, the current attitude toward this reliable form of space power generation is likely to preclude further dramatic performance gains in PV.

CURRENT STATUS

This paradoxical situation has been largely brought about by the success that PV has enjoyed. The tremendous increase in spacecraft traffic and their very high unit cost has occurred in part because a reliable power generation approach, PV, has been demonstrated and proven in space. However, in order to reduce the risk involved in operating a high cost spacecraft, decisions on the subject of new PV technology are mostly resolved in favor of heritage rather than performance. This management approach has acted as a brake on PV progress at the spacecraft level, thus leading to the current unfavorable perception of PV.

The perception of PV at the organizational levels where technology support decisions are made seems to be that it is a mature technology with limited growth potential. In turn, this has caused attention to be given to unproven space technology competitors such as nuclear reactors and solar thermal dynamic systems. This perception has led to a severe decline in funding support for PV with no clear indications that the trend will be reversed in the immediate future, a self-fulfilling prophecy.

Because these competing power generation approaches have not yet operated in space, it is relatively easy for their proponents to forecast performance characteristics that are significantly superior to the state-of-the-art PV systems now powering operational spacecraft. Here, too, the success of PV acts to prevent its proponents from optimistically projecting performance characteristics that meet the forecasts of the competing systems because there is an existing base of sound information available for PV performance forecasting. Unfortunately, the decision maker has no way to factor in the inherently conservative attitude of the users of space PV which has acted to significantly reduce the rate of progress that PV has demonstrated in space.

Another trend that acts to further handicap progress involves the DOD, a major supporter of PV technology. DOD PV requirements, which in the past closely matched those of NASA, have diverged significantly as the result of survivability concerns. Thus, space PV research has lost most of the benefits that common NASA and DOD objectives provided.

Future DOD requirements, driven by the SDI, are for operational power levels orders of magnitude greater than today's PV systems. This unquestionably justifies the pursuit of non-PV power generation options. It does not, however, justify the opinion that solutions to ultra-high space power needs can be automatically translated to significantly lower power levels. Unfortunately, this attitude seems to be gaining some degree of acceptance, further reducing advocacy for a viable PV program.

SURVIVING THE NEXT DECADE

Although the current situation is distressing, the workshop members agreed that PV has a future for providing the power for such ambitious objectives as geosynchronous platforms, electric propulsion, growth Space Station and a lunar base. Thus, the issue becomes one of sustaining the PV infrastructure which includes the space solar cell suppliers, NASA and DOD organizations that provide funding for the development of advanced PV and the cadre of dedicated researchers who develop the technology.

There is no doubt that at this time PV technology contains more options, with respect to solar cell materials, for significantly enhancing space power performance than have existed since the demonstration of the solar cell. This is due in part to the substantial commitment of resources made by the DOE in the area of PV. The technical momentum generated by the recent emphasis of terrestrial research on high efficiency has provided a major infusion of ideas and technical talent into space PV. It is essential that this be encouraged.

Unfortunately, current resources devoted to space PV research and technology development cannot provide the proper level of support necessary to bring all the emerging cell technologies such as GaAs, cascade, InP and amorphous silicon to technical readiness. Priorities must be established to maximize the impact of the relatively limited funding likely to be available for space PV in the next five to ten years.

There are a number of ways this might be accomplished. NASA and DOD could agree that each would only fund one cell technology to avoid redundant support. There could be cooperative ventures between DOE and NASA or DOD to accelerate a particularly promising cell technology. Space PV support agencies could leave PV cell development to the DOE and concentrate on testing and evaluation of DOE developed technology. All solar array and systems associated development could be eliminated and all resources devoted to advanced solar cell technology.

Assuring that the cell suppliers survive this bleak period is a more challenging problem. Its solution involves the realization by NASA and DOD that their present research and development policies will lead to either a virtual monopoly or no U.S. supplier of space-qualified solar cells. The current situation with respect to GaAs solar cells is a classic example of what can occur when a particular organization is funded externally in order to supply an advanced solar cell. Solar cell suppliers cannot be expected to bear the burden of transferring new technology since the nature of the space PV market does not allow for a high, constant profit margin. Unless serious attention is given to this situation, it is very possible that foreign suppliers of space-qualified solar cells will be the only option available when PV once more is required to demonstrate its ability to grow in response to space power needs.

A major objective that should be strongly supported by the PV community is developing a realistic strategy that does three things. In proper sequence, it is necessary to: (1) develop and implement an approach to rapidly translate technology from the laboratory to the supplier, (2) provide regular opportunities to verify the reliability of new PV technology in space, and (3) spread out the risk or responsibility for employing new PV technology in flight programs.

The responsibility for developing this strategy should be shouldered by those NASA and DOD organizations involved in supporting PV research and technology development. If this challenge is met, then PV will be properly postured to exploit the opportunities that can exist in the 1990s.

AN OPTIMISTIC SCENARIO FOR THE 1990s

For at least the next five years, power generation options such as nuclear reactor and solar thermal dynamic systems will continue to receive the attention and funding support warranted by their potential. If they succeed in demonstrating their projected performance levels, then the deemphasis of PV technology will have been a correct decision. However, if they show signs of failing to fulfill their promise, attention will once more be directed to PV.

PV will become the only means to support most of the mission commitments now being made on the assumption that alternate, high performance power systems will become a reality. Among these commitments will likely be geosynchronous platforms requiring perhaps 50 kW_e for periods up to ten years, a growth Space Station that needs 300 kW_e for an indeterminant length of time, electric propulsion which could require 100 to 500 kW_e of power that can survive years in the extremely high radiation environment located between LEO and GEO orbits and a lunar base dependent on a central power station that can deliver a magawatt.

What aspects of technology should be emphasized now in order for PV to be in a position to justify the level of support required in the 1990s to sustain the ambitious plans described previously? The workshop members concluded that the ultimate driver is cost.

Cost advantages can be manifested in many ways when considering the PV option. High efficiency translates to a cost advantage in the case of the growth Space Station where orbital induced drag is of paramount importance. Radiation resistance and low weight translate to a cost benefit in the case of long lived geosynchronous platforms and electric propoulsion vehicles used to transfer payloads out of LEO orbit. Weight and operational lifetime mean cost advantages for a lunar central power station. Reliability is perhaps the ultimate cost advantage. Here PV has no competition and can argue its case on flight history and, hopefully, information obtained from flight experiments.

Thus, it is the opinion of the workshop members that no one particular PV technology should be emphasized at this time. However, the fact that a number of viable options exist to meet the various cost associated PV criteria, such as efficiency, weight and radiation resistance, supports the view that PV has a good chance to retain its role as the primary source of power for space missions well into the 21st century.

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